Rotational Kinematics Output and Other Improvements in DYNA3D

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DYNA3D is a main engineering tool for the simulation of transient response of solids and structures to fast, impulsive loadings. This explicit finite element code was originally created to support weapons activities, but over the years has found broader use in other applications, such as infrastructure vulnerability and protection. The code also provides the mechanics functionalities of the highly parallel ParaDyn simulation tool. This project funds the ongoing implementation of user-requested features, general technical support, documentation updates, and Software Quality Assurance (SQA) compliance for DYNA3D.

This project also supports the broader interagency DYNA3D activities through LLNL's Collaborator Program. The Collaborator Program grants access to selected licensed users to LLNL's computational mechanics/thermal codes in exchange for their information, results, and acknowledgement. These collaborative members include our sister laboratories, U.S. government agencies, and other institutions.

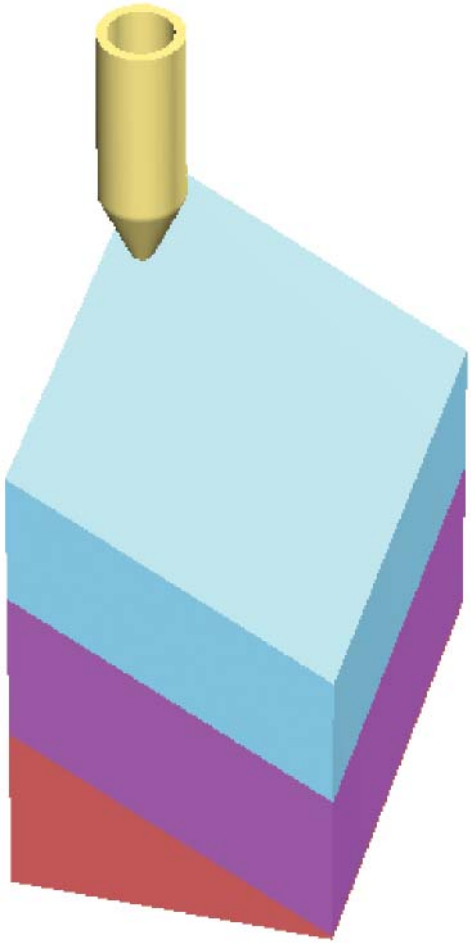

Figure 1. Spinning hollow projectile striking a layered target.

Project Goals

The planned tasks include the implementation of functionalities for various programs needs, enhancement of existing features, the addition of new result display capabilities, and continued compliance work on SQA and the Fortran 95 standard.

Relevance to LLNL Mission

Many Laboratory programs require new functionalities and technical support to complete their missions. Some of these programs and projects involve the Laboratory's collaboration with other institutions and federal agencies, such as the Los Alamos National Laboratory, Department of Homeland Security, Bureau of Reclamation, U. S. Army Corps of Engineers, the Naval Surface Warfare Center, and selected universities.

FY2007 Accomplishments and Results

Based upon multiple requests, rotational velocity and acceleration histories for an entire model, or parts of the model, were added. These quantities can be output to the full-state visualization database, or designated as

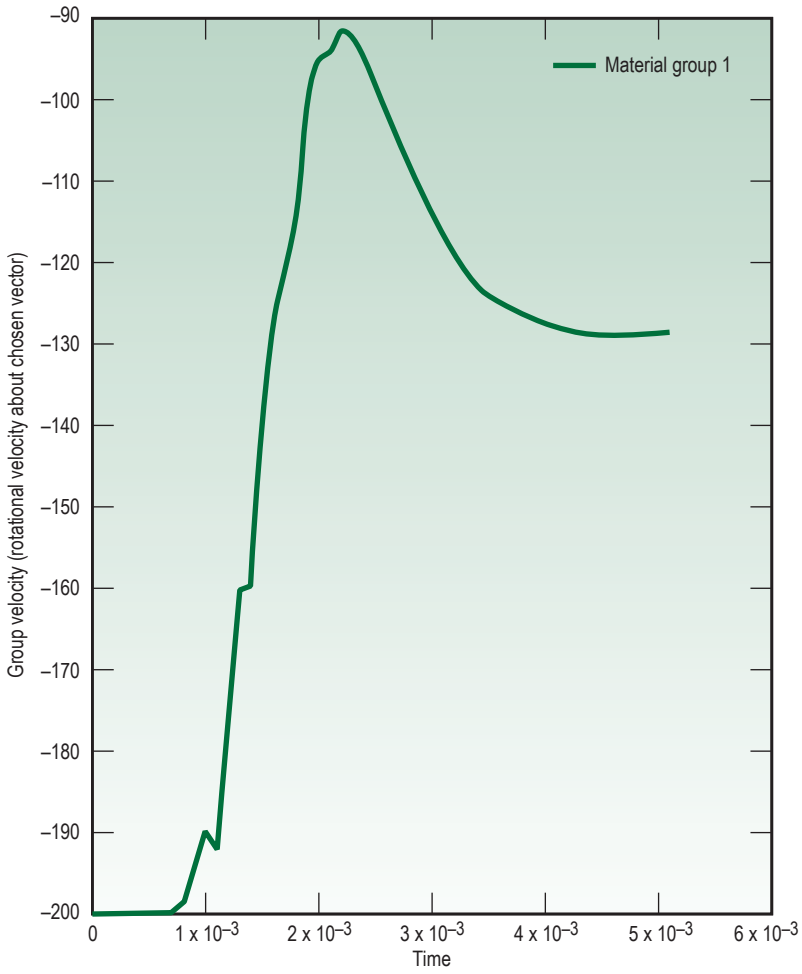

Figure 2. Time history of the projectile rotational velocity about its principal axis. Note that the projectile slows down and partially recovers its spin as it interacts with the target.

one of the limited number of quantities sent more frequently to a dedicated time history database.

These results are made available in terms of components in the global coordinate system or about a user-defined orientation. The user-defined axis may move arbitrarily in space over the simulation time. These quantities supplement their existing translational counterparts in providing the users more detailed understanding of the structure's overall motion or relative motion between parts.

A generic hollow projectile with a blunt nose impacting an inclined flat target surface, shown in Fig. 1, is used as an example. The projectile, modeled by finite elements with isotropic elastic properties, is traveling with an initial translational velocity along with a rotational velocity about its principal axis. The target, modeled by the penetration load-predicting code PENCURV3D, contains layers of materials of different stiffness. Figure 2 shows the projectile's change of spin velocity about its principal axis as it interacts with the target.

The Rayleigh damping features in DYNA3D have been effective tools for achieving quasistatic response, stress initialization, shock noise reduction, and other applications. We made the mass-proportional part of the damping more versatile by excluding selected rigid bodies at the user's choice. This capability, combined with the existing rigid-deformable material switching feature, provides a valuable means to avoid undesirable damping-induced motion slowdown. For the stiffness-proportional part of this feature, a more user-friendly input allows direct specification of fraction of critical damping, and damping frequency is added.

FY2008 Proposed Work

Targeted efforts include general technical support for DYNA3D users, the addition of user-requested capabilities, and the ongoing modernization toward Fortran 95-compatible and SQA-compliance work.

A modified Mili surface capability with more essential attributes is near its completion. This will be integrated into DYNA3D and enable many additional state variables and parameters to be included in the output databases for visualization by analysts.

We will evaluate the possibility of identifying element facets that belong to a model's exterior surfaces. These facets may be assigned special attributes or properties for strengthened numerical stability. Targeted applications include augmented hourglass control and contact surface smoothing.